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[54] HORIZONTAL VIBRATORY CENTRIFUGE

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[51] **Int. Cl.**[6] **B04B 3/06**; B04B 7/08

[52] **U.S. Cl.** **210/370**; 210/380.3; 210/360.1; 210/385; 494/36; 494/47; 494/48

[58] **Field of Search** 210/360.1, 384, 210/385, 370, 380.3; 494/36, 47, 48

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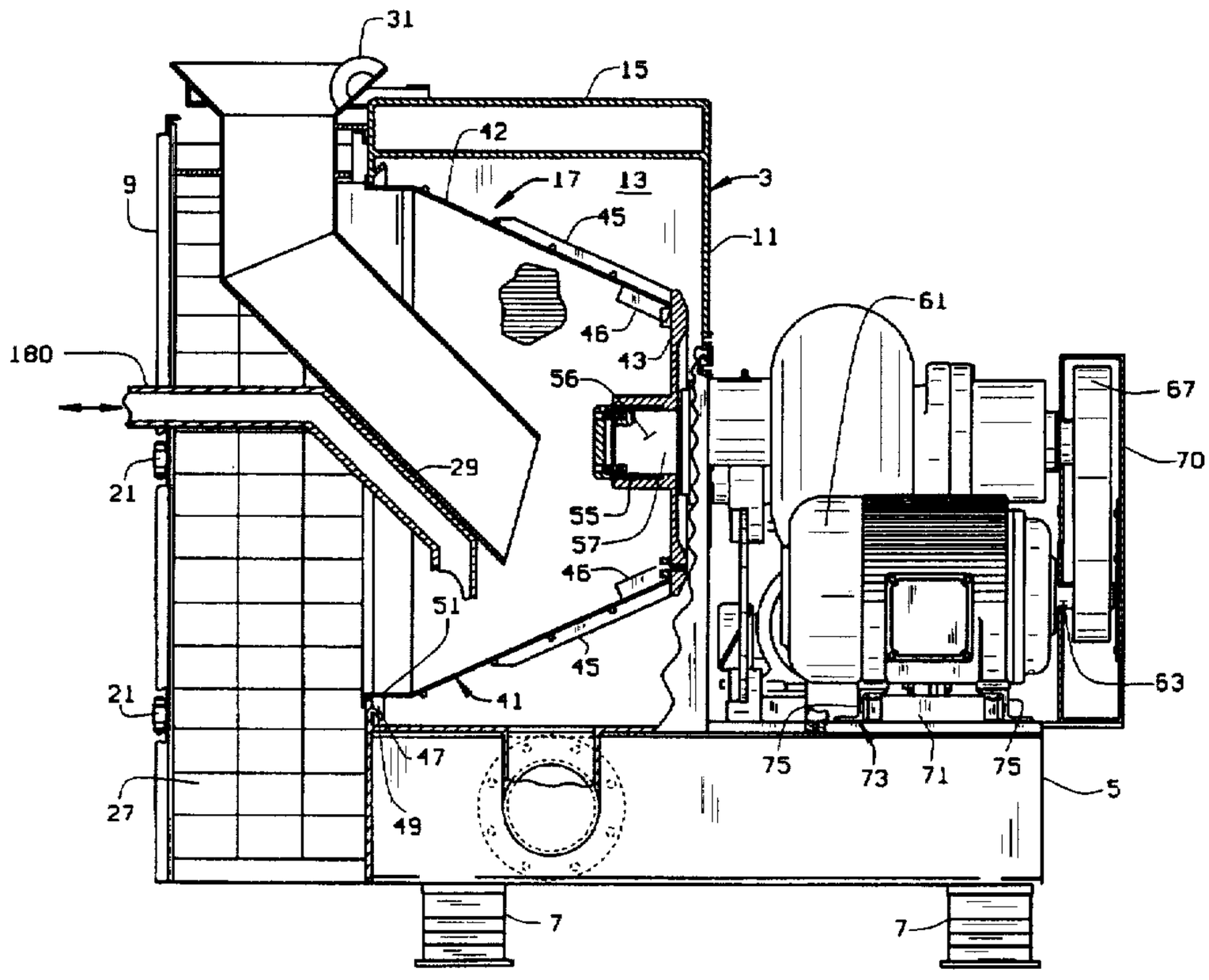
Primary Examiner—Thomas M. Lithgow

[57] **ABSTRACT**

A horizontal screen separator of the present invention includes a base having a housing mounted thereon which contains an horizontal screen basket for receiving product to be dried. The basket is rotatably and vibrationally driven to dry the product. The separator includes two motors, one to impart rotational motion to the basket and the other to impart vibrational motion to the basket. The basket is rotatably fixed to a shaft driven by the rotating motor. The vibratory motor drives a shaft, operative contact with the rotating shaft, having an eccentric mounted thereon. The vibratory motor drives the vibratoy shaft to induce vibration in the basket. The basket also includes a lip or extension formed from screen as a right cylinder to increase the drying time of the product.

16 Claims, 6 Drawing Sheets



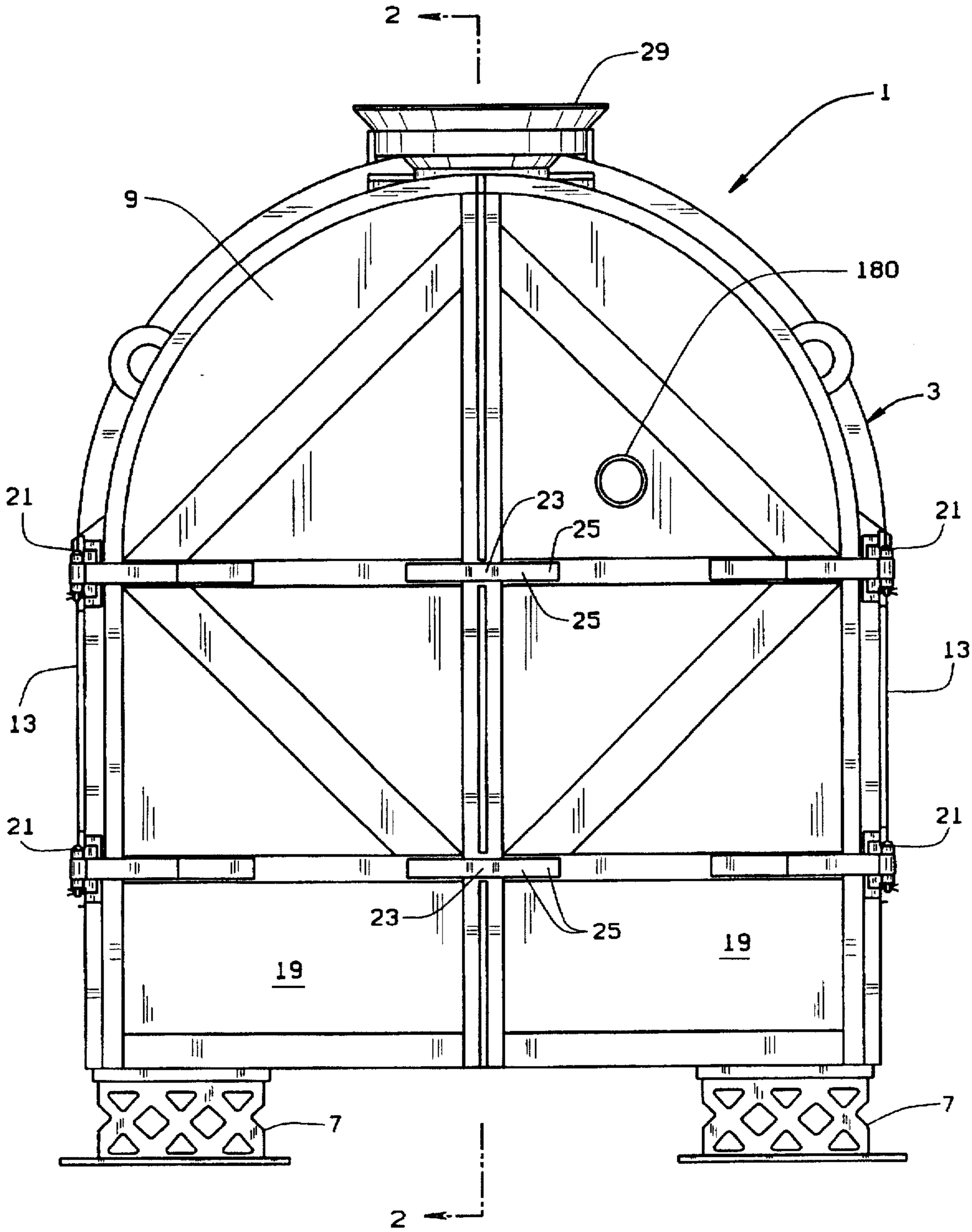
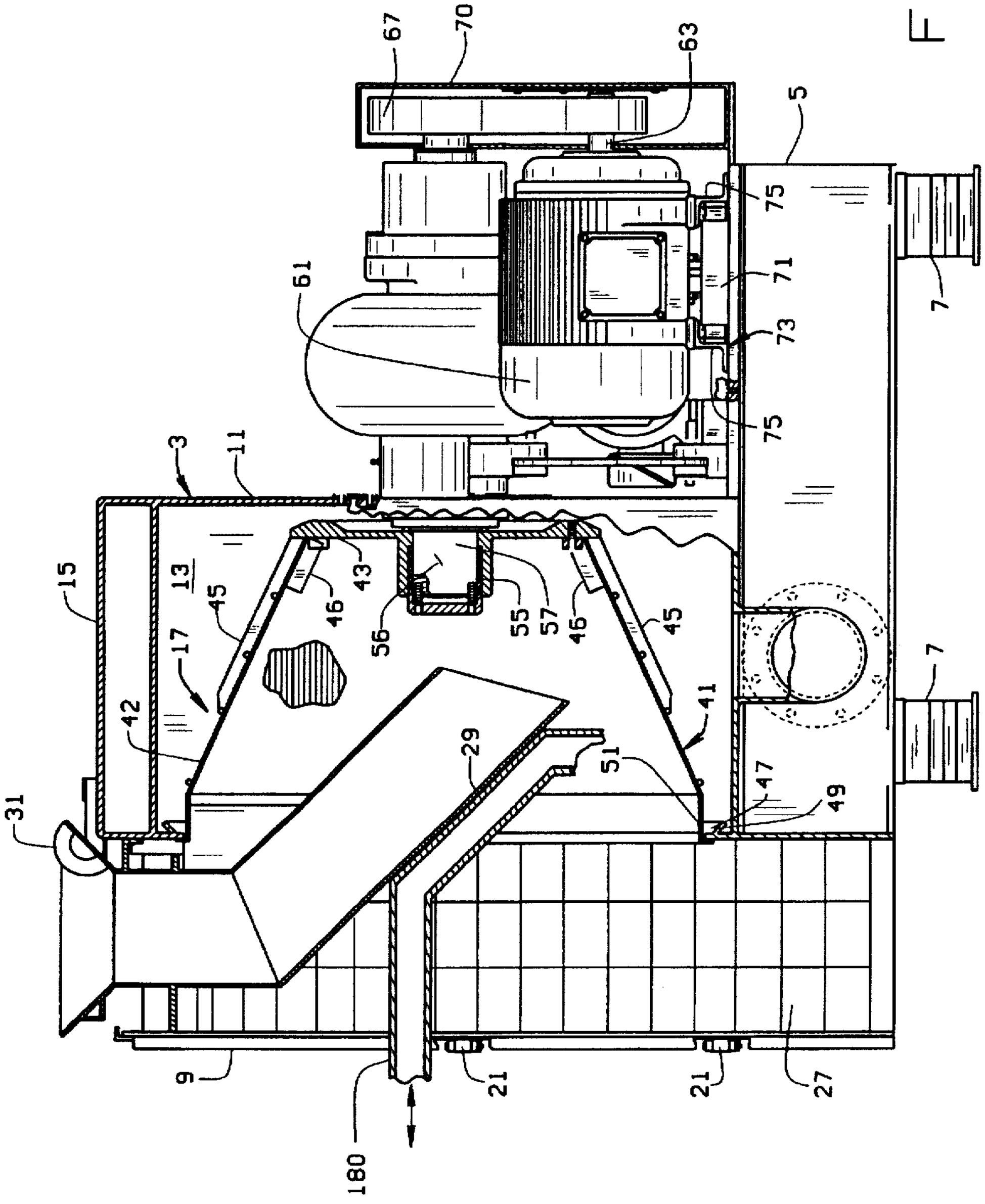


FIG. 1

FIG. 2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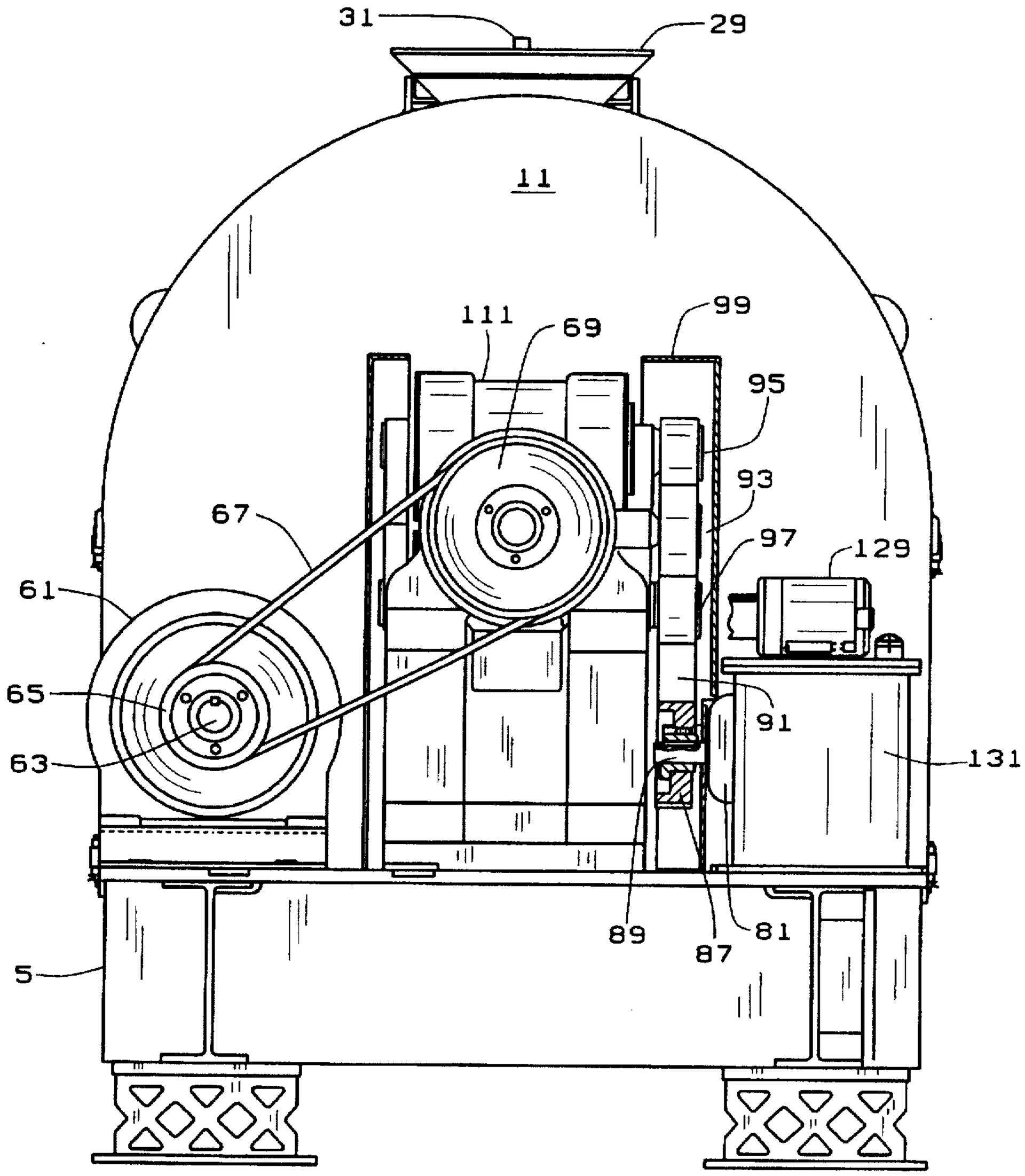
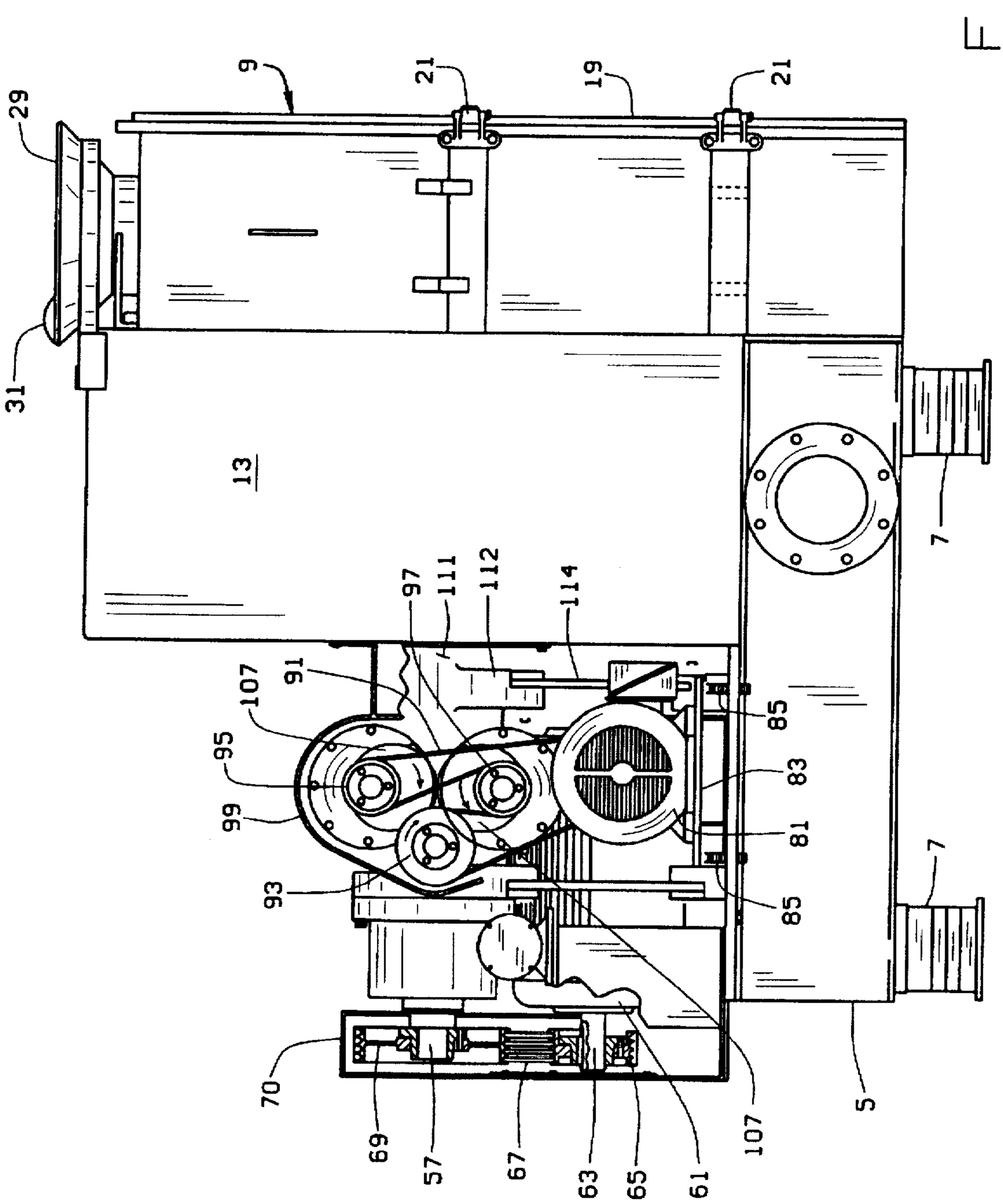


FIG. 3

FIG. 4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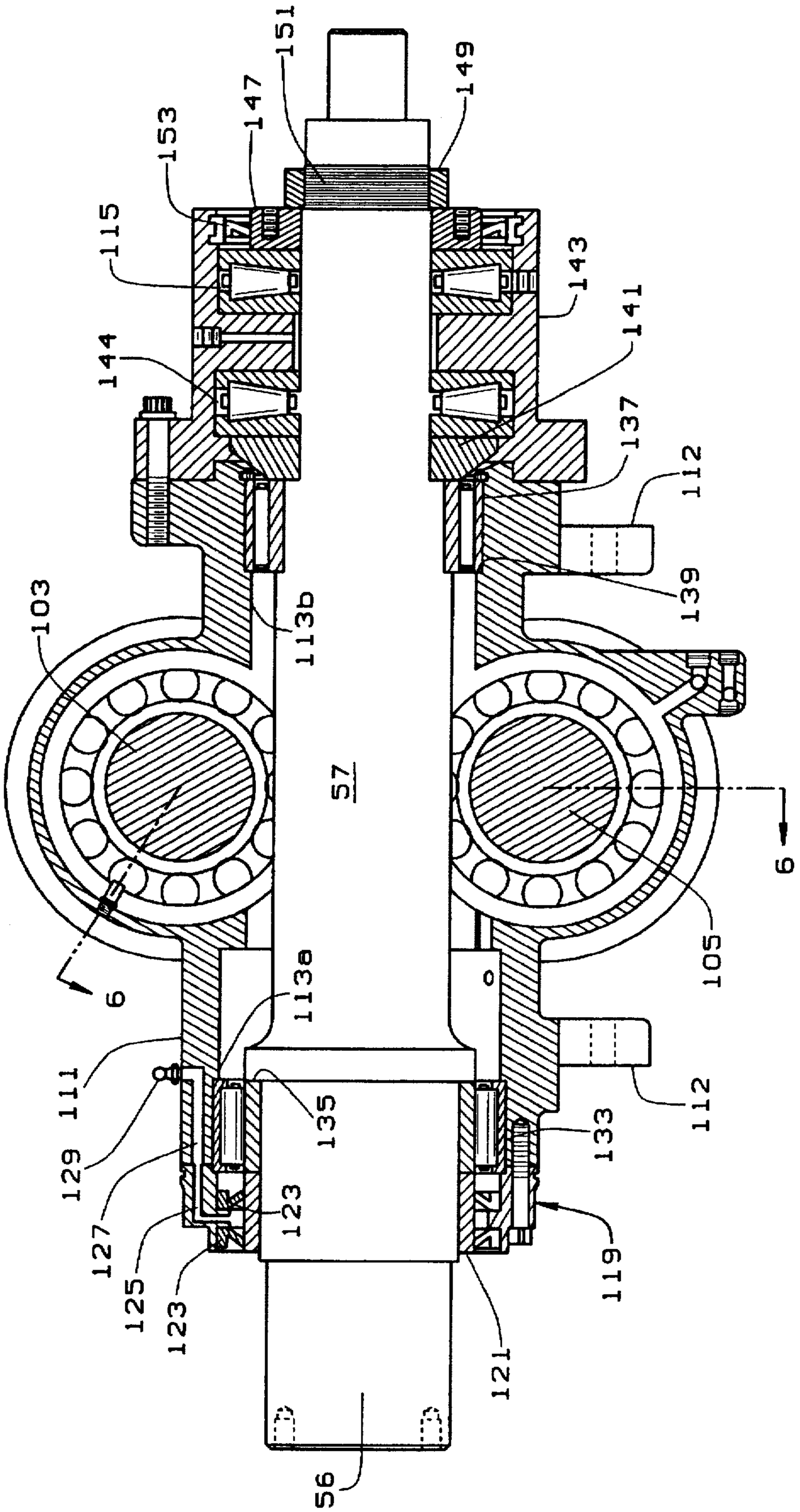
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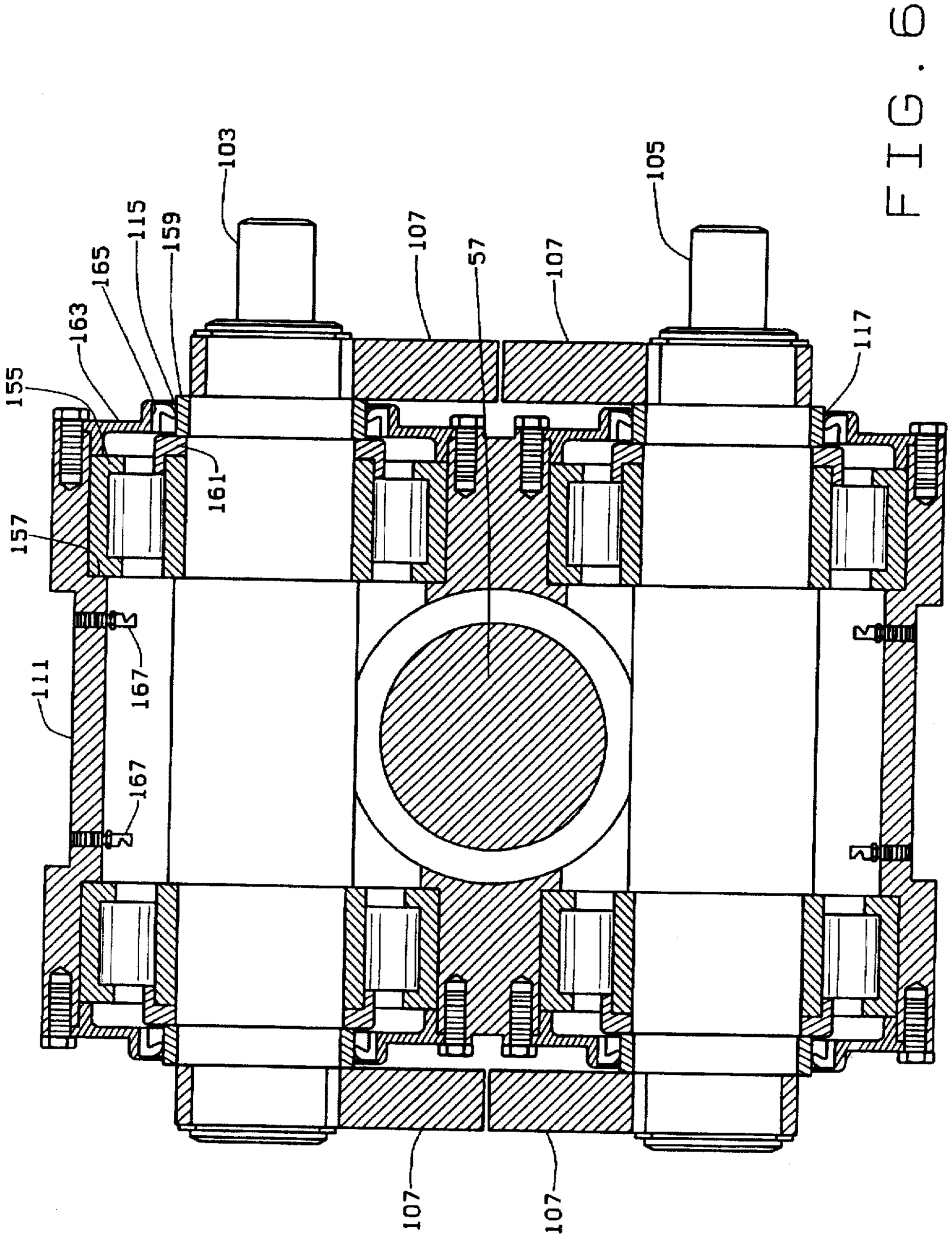
FIG. 5

FIG. 6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HORIZONTAL VIBRATORY CENTRIFUGE

BACKGROUND OF THE INVENTION

This invention relates to centrifugal separators, and, in particular, to a centrifugal separator which incorporates vibratory motion.

Centrifugal separators or centrifuges are generally used to separate or remove liquid from solids, such as coal, ore, or small parts. There are two basic types of screen centrifuges presently in use: screen-scroll and vibratory. The screen-scroll separator is a higher G (centrifugal force) machine that controls the flow of solids over a screen surface with a scroll or auger type of conveyor. Liquids are forced off the solids' surfaces and through the screen by centrifugal forces. The vibratory centrifuge is a low G machine that conveys solids over a screen surface with oscillating or vibratory motion. Both machines are best suited for a certain range of particle sizes and both have inherent advantages and disadvantages.

The screen-scroll centrifuge is capable of much higher G's under most conditions and, as a result, will provide more efficient dewatering (or drying). However, the flights or conveyors force the particles being centrifuged to form thin ribbons along each flight. Due to high exposure of all the particles to the screen, most small particles that will pass through the screen's openings will go through. This is especially true when a large amount of water is contained in the feed. The high G's combined with the loss of fine or small particles produces a very dry product with a poor recovery.

The normal vibratory centrifuge cannot be operated at high G's due to its limiting vibratory conveying capacity. Due to a thick bed that is maintained on the screen surface there is not much loss of solids through the screen openings. This is advantageous in that it makes the vibratory unit a higher recovery device, and thus more efficient machine. However, the thick bed also reduces the drying or dewatering that occurs. Thus, the current vibratory machines provide high recovery efficiency, but will not remove as much water or liquids as will the screen-scroll machines.

All screen type centrifuges have a loss of fine particles that simply wash through the screen. Solid bowl centrifuges are more efficient in the recovery of fines because they serve as a settling area that forces solids or heavies to the outer wall to be conveyed out over a sloped area. Later designs have included a screen at the end of the sloped area to enhance dewatering of solid particles, such as coal. Solids discharged through the screen are recirculated into the solid bowl portion of the centrifuge and, therefore, the solid bowl centrifuges give a very high recovery. However, the solid bowl centrifuges are expensive to obtain, are expensive to operate, and require a larger amount of power than the screen centrifuges.

SUMMARY OF THE INVENTION

One object of the present invention is to provide a screen separator for separating solid particles from water.

Another object is to provide such a separator which will have a high recovery rate.

Another object is to provide such a separator which will deliver a substantially dry product.

Another object is to provide a filter media bed that will allow the addition of fine particulates, such as froth flotation, over the bed to promote dewatering while retaining fine solids.

Another object is to provide such a separator which employs both centrifugal and vibratory motion.

Another object is to provide such a separator which is less expensive to produce and operate than current high recovery separators.

These and other objects will become apparent to those skilled in the art in light of the following disclosure and accompanying drawings.

In accordance with the invention, generally stated, a horizontal screen separator of the present invention includes a base having a housing mounted thereon which contains a horizontal screen basket for receiving product to be dried. The basket is rotatably and vibrationally driven to dry the product. The separator includes two motors, one to impart rotational motion to the basket and the other to impart vibrational motion to the basket. The basket is rotatably fixed to a shaft driven by the rotating motor. The vibratory motor drives a shaft which is in operative contact with the rotating shaft and which has eccentric weights mounted thereon. The vibratory motor drives the vibratory shaft to induce vibration in the basket. The shafts are preferably driven by pulley and belt systems. To compensate for stretching of the pulleys, the motors are adjustibly mounted to the base. One of the motors is slidably mounted to the base for horizontal movement, and the other is mounted for vertical adjustments.

The basket also includes a lip or extension formed from screen as a right cylinder to better control the bed depth and to increase the drying time of the product. The horizontal screen separator includes a screen basket, the basket includes a base, and a screen, which is secured to the base, and the screen having a generally frustoconical shape, with the axis of the basket lying along a generally horizontal line. It is this screen basket that is both rotated and oscillated simultaneously, during the separation process. The separator includes its screen that forms an included angle lying on a range from about 14° to 25° from the horizontal axis, and it includes its screen extension, as previously reviewed, at the larger end of the screen that is remote from the base. The screen extension is formed generally as a short right-angled cylinder. The separator further includes a rotating motor, that rotates the screen, the motor including a shaft having a pulley mounted on an end thereof, the rotating shaft having a second pulley mounted on that opposite end thereof, and an endless belt extending around said pulleys so that said motor can drive said rotating shaft, and transmit from 250 to 700 G's of centrifugal force to the material being processed. In addition, as previously explained, the oscillating means of the device includes rotatable eccentrics, and the eccentrics are mounted to at least one vibratory shaft which extends in an angle to the rotating shaft, said vibratory shaft being adjacent said rotating shaft, and said vibratory shaft being rotatably driven to rotate the eccentrics to induce oscillatory motion in the rotating shaft. Through this manner the vibratory means conveys approximately 10 to 30 G's of force, or exceeding thereof, to accomplish the proper conveyance of the materials as it is being processed by the separator. In addition, that right-angled cylindrical extension portion of the screen increases the overall solids retention time, within the screen and basket, during separation, thus improving the dewatering efficiency and increasing the bed depth, of the material, as it forms upon the screen, during the filtering processing, and actually improves the filtering bed and pad for the screen through the use of the material itself to act as a filter for an overlay of small particulate material that achieves something similar to a froth flotation. Solutions containing fine solids can be applied over the formed

filter media or bed, to filter out the solids while allowing the liquids to pass through the bed, and the screen of the basket, under centrifugal force. A feed tube may be used to apply the froth and fines to the bed to achieve the more efficient dewatering.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a front elevational view of a separator of the present invention;

FIG. **2** is a cross-sectional view taken along line **2—2** of FIG. **1**;

FIG. **3** is a back elevational view of the separator;

FIG. **4** is a side elevational view;

FIG. **5** is a cross-sectional view of a drive assembly for introducing vibration into the separator; and

FIG. **6** is a cross-sectional view of the drive assembly taken along line **6—6** of FIG. **5**.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the FIG. **1**, reference numeral **1** indicates one illustrative embodiment of a separator of the present invention. Separator **1** includes a separator housing **3** which rests upon a base **5**. Base **5** rests on a series of vibration and noise dampening cushions **7** that support the housing above the floor of an industrial plant in which the separator is located. The cushions **7** may be made of any type of durable rubber or other resilient polymer that effectively dampens the transfer of any vibrations to the floor or the surrounding vicinity of the plant, and also lessens the noise associated with the operation of the separator.

The separator housing **3** has a front **9**, back wall **11**, sides **13**, and a top **15**. A separator assembly **17** is rotatably mounted in housing **3**. The front of housing **3** defines a pair of doors **19** which are pivotally mounted to sides **13** by hinges **21**. The doors, which allow access to the interior of housing **3** for collection of product, are maintained closed by a latch **23**, which is secured to one of the doors, and screws or bolts **25** which extend through a free end of the latch into the second door.

The doors **19** are spaced forwardly of base **5** and extend the full height of the separator **1**. The area between the base and the door thus defines a collection area **27**. A chute **29** extends out the top of collection area **27** to allow for the entry of product to be dried into assembly **17**. A handle **31** is formed at the top of the chute and provides a means whereby the chute **29** may be lifted and moved with the aid of a crane, for example. A feed tube **180**, which may be shifted coaxially within the basket, applies froth and fine particulates to the filter bed of material to achieve more efficient filtering and dewatering of the product during separation.

Turning to FIG. **2**, separator assembly **17** includes a basket **41** formed of a generally frustoconically shaped screen **42**. The screen **42** is mounted at its back to a base **43** and along its sides to a plurality of spaced ribs **45** which extend diagonally away from base **43** on an outer surface of the screen. Clamps **46** are secured to the inner surface of screen **42** adjacent base **43** to further secure the screen to the base. Clamps **46** are not as long as ribs **45**. At its front, basket **41** has a circular, peripheral screen extension **47** which moves inside the sloped flange or lip **49**. Lip **49** provides a guide which collects liquids and guides them into area **13**. A generally right cylindrical screen section **51** extends outwardly from the end of screen **41** above the collection area adjacent **27**.

Screen base **43** includes a centrally located inwardly projecting boss **55** which receives an end **56** of a rotatable shaft **57**. Base **43** is rotatably fixed to shaft **57** so that the shaft will rotate or spin the separator assembly **17** when the shaft is rotated.

A rotation motor **61** is mounted on base **5** behind housing wall **11**. Motor **61** has an output shaft **63** having a pulley **65** fixed thereon. An endless belt **67** is mounted about pulley **65** and extends around a second pulley **69**. Pulley **69** is mounted to an end of shaft **57** opposite screen base **43** so that separator assembly **17** will be rotated by motor **61**. Belt **67** is preferably enclosed in a belt housing **70**.

Motor **61** is preferably mounted on a pull bar assembly **71** which is slidably received in a slide **73**. Slide **73** includes two spaced-apart, generally S-shaped brackets **75** which are secured to base **5** with bolts or the like. The ability to slide motor **61** allows for adjustment of the motor position to compensate for stretching of the belt **67** and for replacement of the belt.

Turning to FIG. **4**, a vibratory motor **81** is mounted on base **5**. Preferably, motor **81** is mounted to a mounting plate **83** which is adjustibly mounted to base **5** by adjustable bolts **85**. Motor **81** drives a pulley **87** which is mounted to the end of the motor's shaft **89**. An endless belt **91** extends around pulley **87**, an idler pulley **93**, and two vertically spaced pulleys **95** and **97**. The pulleys **87**, **93**, **95**, and **97** and belt **91** are enclosed by a belt guard **99**.

Pulleys **95** and **97** drive two shafts **103** and **105** which, as best seen in FIGS. **5** and **6**, extend perpendicularly to the shaft **57** which is connected to the separator assembly **17**. As can be seen, shafts **103** and **105** are positioned on opposite sides of shaft **57** and are in operative contact with shaft **57**, as will be explained below. Shafts **103** and **105** each have a pair of eccentric weights **107** fixed on the ends thereof. Retaining rings are used to secure the weights to the shafts. Preferably, the eccentric weights of the two shafts are 180° out of phase with each other. In other words, as seen in FIG. **6**, when the weight of shaft **103** extends downwardly, the weight of shaft **105** extends upwardly. The weights of a single shaft, however, are mounted to the shaft in phase with each other—both eccentrics extend in the same direction. When shafts **103** and **105** are driven by motor **81**, the weights **107** will create an oscillating motion in the shafts **103** and **105**. Because the weights are out of phase from each other by 180°, the oscillation of the two shafts will be out of phase by 180°. Because the shafts are in contact with shaft **57**, the shafts **103** and **105** will induce a vibratory motion in shaft **57** to vibrate the separator assembly **17**.

The shafts **57**, **103** and **105** are enclosed by a drive housing **111**. Housing **111** includes downwardly extending flanges **112**. Leaf springs **114** are connected to and extend between flanges **112** and motor base **5** to secure the housing **111** to the base. Housing **111** is shown in detail in FIGS. **5** and **6**. The housing includes three pairs of opposing ports **113**, **115**, and **117**, through which shafts **57**, **103**, and **105** are journaled, respectively. End **56** of shaft **57** is received in a socket head **119** which is secured to housing **111** at an opening **113***a*. A sleeve **121** journals shaft **57** at the outer edge of head **119**. A pair of spaced oil seals **123** surround sleeve **121**. Grease flow path **125** opens into the space between seals **123** and is in fluid communication with grease flow path **127** in housing **111**. A connector **129** is provided on the surface of housing **111** to provide grease lubication for seal **123**. Shaft end **56** is also journaled through a second needle bearing **133** at the outer end of opening **113***a*. Bearing **133** is seated against a shoulder **135** formed on shaft **57**.

Another needle bearing **137** is formed at the opening **113***b*. Bearing **137** is seated against a shoulder **139** formed in housing **111** and a spacer ring **141**. Spacer ring **141** is journaled on shaft **57**. Bearing housing **143** contains two spaced-apart tapered roller thrust bearings **144** and **145**. A retaining ring **147** and lock nut **149** hold bearings **144** and **145** in bearing housing **143**. Shaft **57** has threads **151** on which lock nut **149** is threaded. An oil seal **153** is provided in retaining ring **147** to prevent lubricating fluid from exiting housing **111**.

In FIG. **6**, the bearing arrangement for shafts **103** and **105** can be seen. The ends of the shaft are identically journaled, and thus only one end of shaft **103** will be discussed. The ends of the shafts are journaled through roller bearings **155** which are seated against a shoulder **157** formed in housing **111**. A seal wear ring **159** surrounds shafts **103** and **105**. An angle ring **161** is sandwiched between an outer edge of bearing **157** and ring **159** to hold an inner race of bearing **157**. An end cap **163** is secured to housing **111** and holds the outer race of the bearing against shoulder **157**. A groove is defined between end cap **163** and ring **159** and receives an oil seal **165**.

A pair of fluid nozzle jets **167** are provided between shoulders **157**. Jets **167** are connected to oil pump **129** to provide lubrication for the bearings and shafts within housing **111**. The various oil seals prevent leakage of oil from the housing.

Motor **61** rotates shaft **57** to provide rotational motion to the basket **41**. Motor **81** drives shafts **103** and **105** which, as described above, induce an oscillation in shaft **57**, to vibrate basket **41**. When material, such as coal, is introduced into basket **41**, it is, thus, both vibrated and rotated. Because the basket is both vibrated and rotated, the vibration and rotational speeds can be adjusted to maintain a thicker bed to reduce the loss of fines. However, the basket can be rotated at speeds higher than standard vibratory screen centrifuges to increase drying efficiency. In this manner, the separator **1** has a high recovery of a dry product. Further, the screen extension **51** at the end of basket **41** increases the residence time of the material on the screen. This further increases the drying or dewatering ability of the separator.

As can be appreciated, the separator **1** produces a dry product with a high recovery. Variations within the scope of the appended claims may be apparent to those skilled in the art. For example, shaft **57** could be driven directly by motor **61**. The various pulleys could be replaced with gears. A single motor could be used to drive all three shafts. Eccentrics could be provided on shaft **57** to induce oscillating motion in that shaft, which would then be passed onto the basket. This would eliminate the need for shafts **103** and **105** and motor **81**. These examples are merely illustrative.

We claim:

1. A horizontal vibratory screen separator for continuously removing liquids from a mixture of granular or fibrous solids, such as coal or paper pulp products, under high forces; the separator including:

a feeder for introducing a feed mixture of liquid and solids into the separator;

a collector for collecting separated product;

a screen basket which receives the feed mixture, said basket including a basket base and a screen which is secured to a first side of said basket base, said screen having a generally frustoconical shape, the axis of said basket lying along a generally horizontal line;

a separator shaft extending from a second side of said basket base;

at least one vibratable shaft in operative contact with said separator shaft, said at least one vibratable shaft being capable of inducing vibrations in said separator shaft as said vibratable shaft is rotated;

a first motor mounted on a separator base and operatively connected to said separator shaft for rotating said basket, said first motor rotating said screen basket at a rate sufficient to transmit about 250 G's to about 700 G's of centrifugal force to the product being separated; and

a second motor mounted on said separator base and operatively connected to said at least one vibratable shaft to rotate said vibratable shaft for vibrating said basket, said second motor rotating said vibratable shaft at a rate sufficient to induce about 10 G's to about 30 G's of centrifugal force for conveying the product being separated along the screen basket.

2. The separator of claim **1** wherein said screen of the basket forms an included angle arranged approximately between 14° to 25° from the horizontal or axis of the screen basket, in the formation of its generally frustoconical shape.

3. The separator of claim **1** and including a screen extension, said screen extension being formed generally as a right angled cylinder, and extending from an end of said frustoconical screen.

4. The separator of claim **1** wherein said first motor is mounted to a slide which is slidably mounted to said base, said slide allowing for horizontal motion of said motor relative to said separator base.

5. The separator of claim **1** wherein said at least one vibratable shaft has an eccentric mounted thereto.

6. The separator of claim **1** including two of said vibratable shafts in spaced apart relation, said vibratable shafts being positioned on opposite sides of said separator shaft.

7. The separator of claim **6** wherein the eccentrics of each said vibratable shafts induces forces that are aligned along the axis of the said rotating shaft.

8. The separator of claim **7** wherein the eccentrics of each vibratable shaft are 180° out of phase and rotated in opposite directions.

9. The separator of claim **1** wherein each said vibratable shaft extends at right angles to said separator shaft.

10. The separator of claim **1** wherein said first motor drives a pulley, said separator shaft having a pulley at one end thereof, and endless belt extending around said pulleys.

11. The separator of claim **10** wherein said first motor is adjustably mounted to said separator base.

12. The separator of claim **11** wherein said second motor is mounted to a motor base which is movably secured to said separator base for vertical movement, said second motor being movable vertically relative to said separator base.

13. A horizontal screen separator for dewatering a feed suspension through a formed filter bed including:

a separator base;

a housing mounted on said separator base;

a rotatable horizontal screen basket contained in said housing, said basket receiving the feed suspension, said basket including a basket base and a screen which is secured to said basket base, said screen having a generally frustoconical shape, the axis of said basket lying along a generally horizontal line;

a screen extension at an end of said basket remote from said base, said extension being formed generally as a right cylinder;

a feed suspension inlet for introducing said feed suspension to be dewatered into said screen basket;

a source of froth and fine particles; and

an inlet for supplying said froth and fine particles into said screen basket so as to increase the efficiency of the separator.

14. The separator of claim **13** including means for vibrating said basket.

15. The separator of claim **14** including a rotatable shaft operatively connected to said basket base for rotating said basket and a rotating motor operatively connected to said rotatable shaft to rotatably drive said shaft; and

said means for vibrating said basket including eccentrics mounted on a second rotatable shaft, said second rotatable shaft being rotatable to produce an oscillating motion, said second rotatable shaft being operatively connected to said first rotatable shaft to induce a vibratory motion in said basket and a vibratory motor operatively connected to said second shaft for driving said second shaft.

16. The separator of claim **13** wherein said feed tube is shiftably mounted coaxially within the basket when depositing said froth and fine particulates therein.

* * * * *